SNL-CTBT-0006

System Test Plan for the INFRASOUND Prototype

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The System Test Plan outlines testing to be performed during the Infrasound Prototype acceptance testing. Most of these tests operate at the system level, not the unit or integration level. The outline of the Test Plan is based on ANSI/IEEE Std. 829-1983, *Test Plan*.

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1. Infrasound Prototype

1.1 Objective

The objective of the infrasound prototype development is to:

A. Provide an infrasound prototype that reliably acquires and transmits near real-time infrasonic data to facilitate the rapid location and identification of atmospheric events and that could be used by the US to fulfill the USG responsibility to install CTBT infrasonic stations.
B. Provide documentation that could be used by the US and foreign countries to procure infrasound systems commercially to fulfill their CTBT responsibilities. Users could procure the system as a turnkey product from a single commercial integration house or procure the components individually and integrate the system themselves.

The objective of the infrasound prototype Development Test and Evaluation (DT&E) is to verify compliance with the System Requirements Document for the Infrasound Prototype (SRD).

1.2 Scope

The System Test Plan (this document) defines the plan and the methods to evaluate the infrasound prototype. The specific tests to be performed are detailed in the Test Procedures (TP). Requirements, for which tests are to be performed, are specified in the System Requirements Document for the Infrasound Prototype, dated August 16, 1996.

1.3 Reference Documents

The documents that govern the infrasound prototype test and evaluation are the:

1. Program Plan for the Infrasound Prototype Development, dated August 12, 1996.
2. System Requirements Document for the Infrasound Prototype, dated August 16, 1996.
3. System Test Plan for the Infrasound Prototype, dated August 18, 1997 (this document).
4. Test Procedures for the Infrasound Prototype, dated August 18, 1997.

SNL and LANL will provide a detailed description of the configuration to be tested based on the latest version of the following support documents:

1. Hardware Design Document (HDD)
2. Commercially provided manuals

1.4 Test and Evaluation Management

Sandia National Laboratories (SNL) and Los Alamos National Laboratory (LANL) are the agencies responsible for testing and evaluating the infrasound prototype. The infrasound prototype testing will be managed by the SNL Test Manager with the assistance of the Test Working Group (TWG).

1.4.1 Test Managers

Dale Breding, SNL, and Rod Whitaker, LANL, will serve as the Test Managers. They will be responsible for the test program, including the test plan and procedures. SNL will write and maintain infrasound prototype test documentation. In addition, the Test Managers have the responsibility to resolve any conflicts that may arise during testing. The test plan and procedures will identify the number and type of tests to be performed.

1.4.2 Test Working Group (TWG)

The TWG provides the overall guidance to the Test Manager for the test program. The TWG has representatives from SNL and LANL. The TWG is chaired by the SNL Test Manager. Specifically, the TWG:

- approves the test plans and procedures,
- provides recommendations to the Test Manager on testing issues, and
- approves the test reports.

1.5 Test Monitors

The Test Monitors have the responsibility to monitor the infrasound prototype test and evaluation (T&E). Test Monitors will document results for each test procedure. Members consist of the TWG or their appointed representatives and invited observers.

1.6 Approach

1.6.1 Infrasound Prototype Testing

Task groups (Section 1.8, page 5) are organized around functionality to be tested. Each group is responsible for a unique set of Test Procedures and recording corresponding test results. The T&E is expected to take several days.

Test Procedures serve as a basic set of required procedures. The task groups should modify or extend them as they see fit to ensure that testing is adequate. For example, a test may begin by observing results on the display, but may be extended to checking documentation, examining source code or adding to the test data set.

1.6.2 Task Group Reports/Summary

Once the task group has completed a test procedure, they will summarize their findings. At the end of each day, each task group will summarize their results for that day.

1.6.3 Status Meetings

Daily status meeting will be held during which each task group will report its findings. If necessary, changes may be made to the schedule.

1.6.4 Evaluation Review

The task group will report its overall findings and conclusions (at the end of testing) to the entire group. Recommendations and issues will be recorded as input to the SNL Test Manager.

1.7 Test Environment

The test environment for the infrasound prototype as installed at LANL, consists of an:

1. **Infrasound Array** - Four array elements that acquire infrasound data.
2. **Intrasite Communications** - Transmits the infrasound, state of health (SOH), and meteorological data from an array element to the receiving station.
3. **Receiving (Host) Station** - Provides data and SOH displays; array element commands; and data transfer to the National Data Center (NDC).

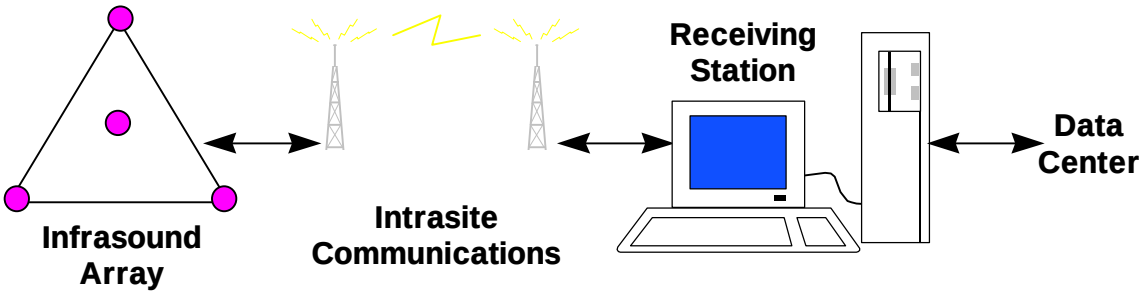

FIGURE 1. BLOCK DIAGRAM OF THE INFRASOUND PROTOTYPE.

Figure 1 shows the triangular infrasound array layout as recommended in the Conference on Disarmament/Ad Hoc Committee on a Nuclear Test Ban/Working Paper 224 and 283. An infrasound array element is located at each corner and one in the center. The prototype spacing will be 1 km on a side, however, the CD working papers provides for an optional spacing up to 3 km.

Each array element acquires infrasound and SOH information, formats the data, and interfaces the data to the intrasite communications for transmission to the receiving station. A detailed block diagram of the components that make up the infrasound prototype is shown is Figure 2. A meteorological station (at the center element)

acquires outside temperature, wind speed, and wind direction, formats the data, and interfaces the data to a separate intrasite communications for transmission to the receiving station.

The receiving station will typically be located near the array site in a building or hut. The receiving station provides the operator with the capability to monitor the array element infrasound data, state of health (SOH), and meteorological information.

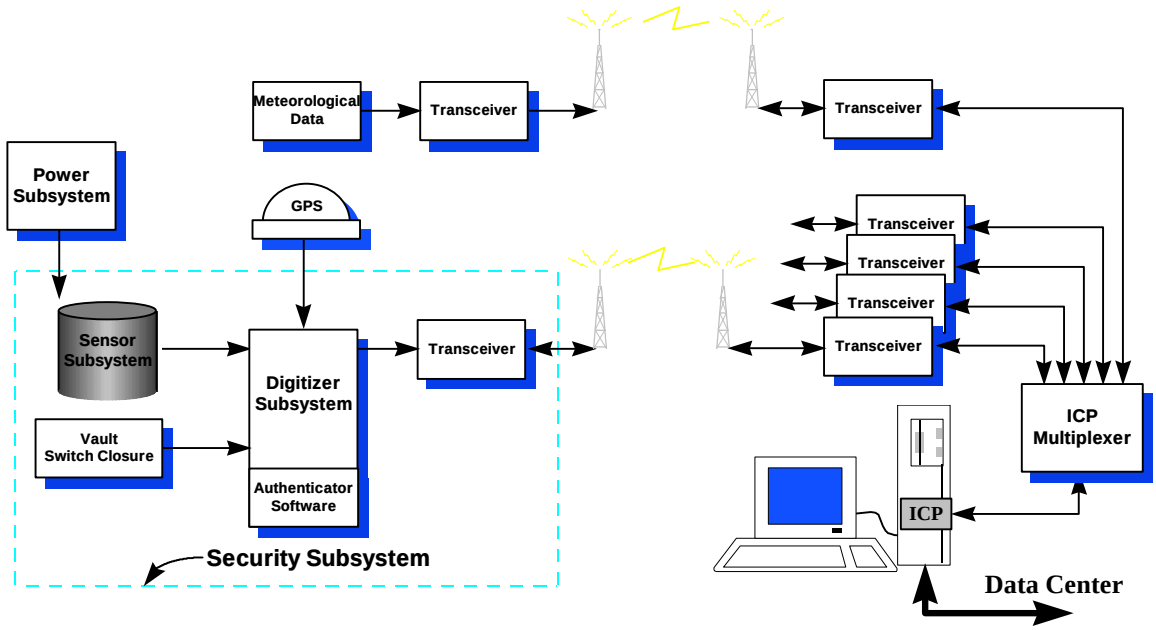

FIGURE 2. DETAILED BLOCK DIAGRAM OF THE INFRASOUND PROTOTYPE.

1.8 Staffing

SNL, LANL, Bechtel Nevada, and AFTAC personnel will be divided into task groups. Each group will be responsible for an area of the infrasound prototype T&E. Note that the lead person for each task group is listed first.

1.8.1 Pre-Test Task Group

Dick Kromer, SNL
Tim Draelos, SNL (Security Features)
Tom Sandoval, Bechtel, Nevada

1.8.2 Inspection/Analysis (I/A) Task Group

Tom Sandoval, Bechtel Nevada
Dick Kromer, SNL

1.8.3 Demonstration Task Group

Rod Whitaker, LANL
Dale Breding, SNL

Tom Kelly, AFTAC

1.9 Schedule

DT&E schedule is shown in Table 1 and will take place after system integration. The final schedule will be distributed to all participants prior to DT&E.

TABLE 1: TEST AND EVALUATION SCHEDULE

Time	Tuesday	Wednesday
0800	1. Introduction 2. Overview 3. TP Intro. 4. Pre-Test Results 5. Infrasound Prototype Testing	Infrasound Prototype Testing (continued)
1200	Lunch	Lunch
1300	Infrasound Prototype Testing (continued)	Infrasound Prototype Testing (continued)
1600	TG Summary	TG Summary

1.9.1 Overview

The system overview will describe the infrasound prototype to be evaluated during the week. Areas to be covered are as follows:

- Array Elements
- Intrasite Communications
- Host Receiving Station
- Intersite (receiving station to NDC) Communications

The agenda discussion will finalize the plans in the following areas:

- Task Groups
- Schedule
- Procedures
- Test Reports

1.9.2 Training

During the evaluation activities, each task group will contain a trained member to perform the test procedures. During the course of the evaluation, members of the team will be present to provide guidance, answer questions about the operations, hardware/software, or to perform functions not explicitly covered by the test procedures.

2. Evaluation Tests

2.1 Verification Matrix Column Definitions

The following are the column definitions for the verification matrix.

2.1.1 Column 1 - SRD Paragraph

Paragraph numbers listed in this column correlate to the paragraphs in the *System Requirements Document for the Infrasound Prototype*.

Example: **3.1.1**

3.1.1 Represents the paragraphs in the *System Requirements Document for the Infrasound Prototype*.

2.1.2 Column 2 - Verification Method (VM)

Verification of compliance with the requirements shall be accomplished by Inspection (I), Analysis (A), Demonstration (D), and/or Test (T) as defined below:

N Not Applicable - Where a requirements verification is not applicable, a code will be entered in the VM column and an appropriate explanation will be given.

I Inspection - An observation or examination of the equipment and/or software generated printouts to determine conformity with requirements that can be verified without analysis, demonstration, or test.

A Analysis - A review or study of data to deduce through the use of mathematical expressions or models, the verification of requirements.

D Demonstration - A qualitative observation of the performance of a function or equipment from which the satisfaction of the requirements concerning that function or equipment can be verified.

T Test - Quantitative observations of the performance of a function or equipment from which the satisfaction of the requirements concerning that function or equipment can be verified by comparison with quantitative criteria such as predicted values, range of values, accuracy's or tolerances.

2.1.3 Column 3 - Requirement Synopsis

This column contains a synopsis of each distinct requirement in the *System Requirements Document for the Infrasound Prototype*.

2.2 Pre-Test Task Group

The verification matrix in Table 2. lists all requirements to be tested by the Pre-Test Task Group and the method by which they will be tested.

TABLE 2: PRE-TEST TASK GROUP VERIFICATION MATRIX.

SRD Paragraph	VM	Requirement Synopsis
3.1.1	**T**	Wideband microbarograph with a flat frequency response from 0.02 to 5.0 Hz.
3.1.2	**T**	Resolution - 0.01 Pa at 1.0 Hz.
3.1.4	**T**	Dynamic range should be at least 80 dB.
3.2.2	**T**	Digitize signal with at least a 20-bit resolution analog-to-digital converter (ADC).
3.2.4	**T**	The digitizer passband (3 dB points) should be at least 0.02 Hz to 75% of the Nyquist Frequency.
3.2.5	**T**	The digitizer attenuation at the Nyquist frequency should be at least 80 dB.
3.2.6	**T**	Digitize signal with a sensitivity of at least 2^{19} counts per +/- 10 volts (differential input) +/- 1.0%.
3.2.7	**T**	Synchronize the digitizer clock to Global Positioning System (GPS).
3.2.8	**T**	Time tag the data with GPS time.
3.2.9	**T**	Timing accuracy for 10 sps shall be 1.0 msec or better.
3.3.1	**T**	Authenticate at those sites that are collocated with seismic stations. The prototype shall authenticate data at one element of the infrasound array.
3.3.3	**T**	Authenticate using a public key standard.
3.3.5	**I**	The authentication module shall be capable of utilizing keys of variable length.
3.5.2	**T**	Provide capability to manually calibrate sensor w/known acoustic source such as a piston-phone.

2.3 Inspection/Analysis Task Group

TABLE 3: INSPECTION/ANALYSIS TASK GROUP VERIFICATION MATRIX.

SRD Paragraph	VM	Requirement Synopsis (Inspection/Analysis)
3.1.3	**I**	Sensor should include noise reduction hoses.
3.1.5	**I**	The analog full scale signal output shall be +/- 2 volts to +/- 10 volts.
3.1.6	**I**	Provide sensor documentation to include operations manual, schematics, parts and replacement list to enable repair to the component level.
3.2.10	**I**	Provide digitizer documentation to include operations manual, schematics, parts and replacement list to enable repair to the component level.
3.2.13	**I**	Digitize SOH with an 8-bit resolution.
3.2.14	**I**	Digitize SOH at 1 sps.
3.3.2	**I**	All array elements should be capable of data authentication.
3.3.4	**I**	Generate a private key and distribute the corresponding public key.
3.3.7	**I**	Provide capability for at least one passive tamper device (to be provided) at each authenticated element.
3.4.3	**I**	Adaptable for use with low-power radio link, buried fiber optic cable or copper cable to transmit data from the sensor site to the receiving station.
3.4.5	**I**	Utilize a separate transmitter to transmit the meteorological data.
3.6.1	**I**	Remote infrasound equipment shall operate on 21.6 - 28.8 volts of direct current (DC) power @ 1 amp maximum.
3.6.2	**I**	A DC-DC converter shall be provided at each array element if supplied data acquisition and communications hardware cannot be operated from 24 VDC. This device should have the same operating and environmental specifications as the array element hardware.
3.6.3	**I**	Utilize a solar array to provide the DC power or alternately provide the DC from a power supply operating from 110 VAC, 60 Hz or 220 VAC, 50 Hz.
3.6.4	**I/A**	Provide battery backup to operate the infrasound array for a minimum of 72 hours.
3.7.1	**I**	Install on a level area of 0.25 km^2 around each sensor (Note: this requirement is too restrictive). Each prototype element shall be installed on an area level within 2.0 m over an area of 0.010 km^2.

SRD Paragraph	VM	Requirement Synopsis (Inspection/Analysis)
3.7.2	**I**	The infrasound prototype shall be installed in an area with some ground cover such as tall grass, shrubs or trees to aid wind noise reduction.
3.7.3	**I**	The prototype shall not be installed on sites with significant average winds.
3.7.4	**I**	Sensors shall not be placed downwind of local topographic features that could generate turbulence which would raise the noise level.
3.7.5	**I**	Sensors shall not be placed in areas with local depressions in terrain (such as bowls) that can allow rain accumulation causing flooding problems.
4.1.4	**I**	Adaptable for use with low-power radio link, buried fiber-optic cable or copper cable to transmit data from the sensor site to the receiving station.
4.1.5	**I**	Spread spectrum RF modems are required for this prototype.
4.3.5	**I/A**	Provide data storage for 1 month.
4.4.2	**I**	Utilize ordinary telephone communications (cable or satellite).
4.5.1	**I**	Use commercially available 110 volt, 60 Hertz and 220 volts, 50 hertz alternating current (AC) power.
4.5.2	**I**	The host receiving station should utilize a UPS to provide backup power to critical equipment (multiplexer, etc.) for 12 to 24 hours.
5.1.1	**I**	The array shall have four elements, Three arranged in an equilateral triangle and the fourth element at the center.
5.1.2	**I**	The array spacing shall 1 km one each side of the equilateral triangle.
5.1.3	**I**	Microbaragraph shall operate within specifications over the temperature range of -25.0 ^{o}C to 50.0 ^{o}C up to 90% humidity, non-condensing.
5.1.4	**I**	Remote power system shall operate within specifications over the temperature range of -25.0 ^{o}C to 50.0 ^{o}C up to 90% humidity, non-condensing.
5.1.5	**I**	Remote equipment (digitizer, communication equipment, etc.) except microbarograph and power system shall operate within specifications over the temperature range of -10.0 ^{o}C to 45.0 ^{o}C up to 90%, non-condensing
5.1.6	**I**	Remote equipment shall survive storage temperatures of -25.0 ^{o}C to 55.0 ^{o}C.
5.1.7	**I**	Remote equipment operation elevation shall be sea level up to 10,000 ft above sea level.
5.1.8	**I**	Commercial shock and vibration requirements are acceptable.

SRD Paragraph	VM	Requirement Synopsis (Inspection/Analysis)
5.1.9	**I**	The host receiving station equipment shall be capable of operating in a normal office environment.
5.1.10	**I**	Provide a full(parts and labor) warranty for 1 year for the digitizer and communications systems.
5.2.1	**I**	Standard commercially available products shall be used whenever possible.
5.2.2	**I**	Integrate and assemble all equipment in accordance with best commercial practices.
5.2.3	**I**	System safety engineering shall be an integral part of the system integration and a primary consideration.
5.2.3.1	**I**	The system design shall provide for adequate safety of personnel during system installation, operation, and maintenance. System components shall not be combined in such a manner as to exceed reasonable weight limits.
5.2.3.2	**I**	All voltage sources shall be adequately guarded so as not to present a safety hazard to operations and maintenance personnel.
5.2.3.3	**I**	The infrasound equipment shall, where practicable, contain transient protection circuits located between all outdoor cables or lines and the infrasound equipment. These circuits shall protect equipment against lightning-induced transients, electrostatic charge, or other over-voltage conditions that may appear on the signal and power lines connected to the equipment. The protector circuit elements shall dissipate the energy in the over-voltage transient or conduct it to the ground. When overloaded, the transient protector elements shall, where practicable, fail in a safe mode.
5.3.1	**I**	Operate unattended for at least one year.

2.4 Demonstration Task Group

TABLE 4: DEMONSTRATION TASK GROUP VERIFICATION MATRIX.

SRD Paragraph	VM	Requirement Synopsis (Demonstration)
3.1.7	**D**	Provide the sensor instrument response in 's' plane pole and zero format.
3.2.1	**D**	Receive one channel of analog data from an infrasound sensor.
3.2.3	**D**	Digitize signal to provide a data stream at a sample rate of 10 samples per second (sps).
3.2.11	**D**	Provide the digitizer response in the 's' plane pole and zero format.
3.2.12	**D**	Collect the following SOH at the each array element: DC voltage, digitizer temperature, and tamper detection such as active switch closures.
3.2.15	**D**	Collect the following meteorological data at the center elements: Wind speed, Wind direction, Outside temperature.
3.3.6	**D**	Provide capability for a active tamper device (switch closure type) at each element.
3.4.1	**D**	Employ error detection, such as CRC, and retransmission protocols for all data from the sensor site to the multiplexer.
3.4.2	**D**	Transmit the following digital data from the each element to the multiplexer: one channel of infrasonic data, three channels of SOH data from each of four array elements, three channels of meteorological data from the center element.
3.4.4	**D**	Spread spectrum RF modems are required for this prototype.
3.5.1	**D**	Provide the capability to calibrate sensor and digitizer electronics with a pulse or step signal.
4.1.1	**D**	Employ error detection and retransmission protocols for all data from the sensor site to the multiplexer.
4.1.2	**D**	Receive the following digital data from the each array elements: one channel of infrasonic data, three channels of SOH data,
4.1.3	**D**	Receive three channels of meteorological data from the center element.
4.2.1	**D**	Receive 1 channel of infrasound data and 3 channels of SOH data from each of 4 array elements and 3 channels of meteorological data from the center element.
4.2.2	**D**	Output one channel consisting of 4 channels of infrasound data, 3 channels of meteorological and 12 channels of SOH data.
4.3.1	**D**	Provide the capability to display four channels of infrasound data on a scrolling or buffered snapshot display.

SRD Paragraph	VM	Requirement Synopsis (Demonstration)
4.3.2	**D**	Provide the capability to display all SOH data in a tabular format and a scrolling or buffered snapshot display.
4.3.3	**D**	Send all infrasound and SOH data to the NDC in the Alpha protocol.
4.3.6	**D**	Store all infrasound data in the CSS format
4.4.1	**D**	Send all infrasound data continuously to the IDC. The prototype shall send all infrasound data continuously to the NDC for retransmission to the IDC.
4.4.4	**D**	Employ error detection such as CRC, and retransmission protocols for all data from the receiving station to the NDC.
4.4.5	**D**	Transmit the following digital data from the receiving station to the NDC: four channels of infrasonic data, three channels of meteorological data, twelve channels of SOH data.

Tests That Are Not Applicable

4.2.3	**N**	The serial multiplexer could be located at the center element. If so, the temperature requirements for the array elements would apply.
4.3.4	**N**	Provide a capability to respond to NDC/IDC requests for segments of stored data.
4.4.3	**N**	A packet switch network could be used to transmit data between the receiving station and the NDC.